

Knowledge Acquisition For Reconstruction And Identification Of Dimensionless Groups By Means Of Case Based Reasoning

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In the present study...

- a methodological framework has been developed in terms of a logical flow chart
- including 11 activity stages and 7 decision nodes,
- to acquire/process/store/retrieve knowledge for reconstruction and identification of these groups
- Case Based Reasoning (CBR), especially modified to meet the needs of this work, has been used for tracing causality paths by similarity and making correction suggestions
- Two case examples are presented to prove the functionality of the proposed methodology

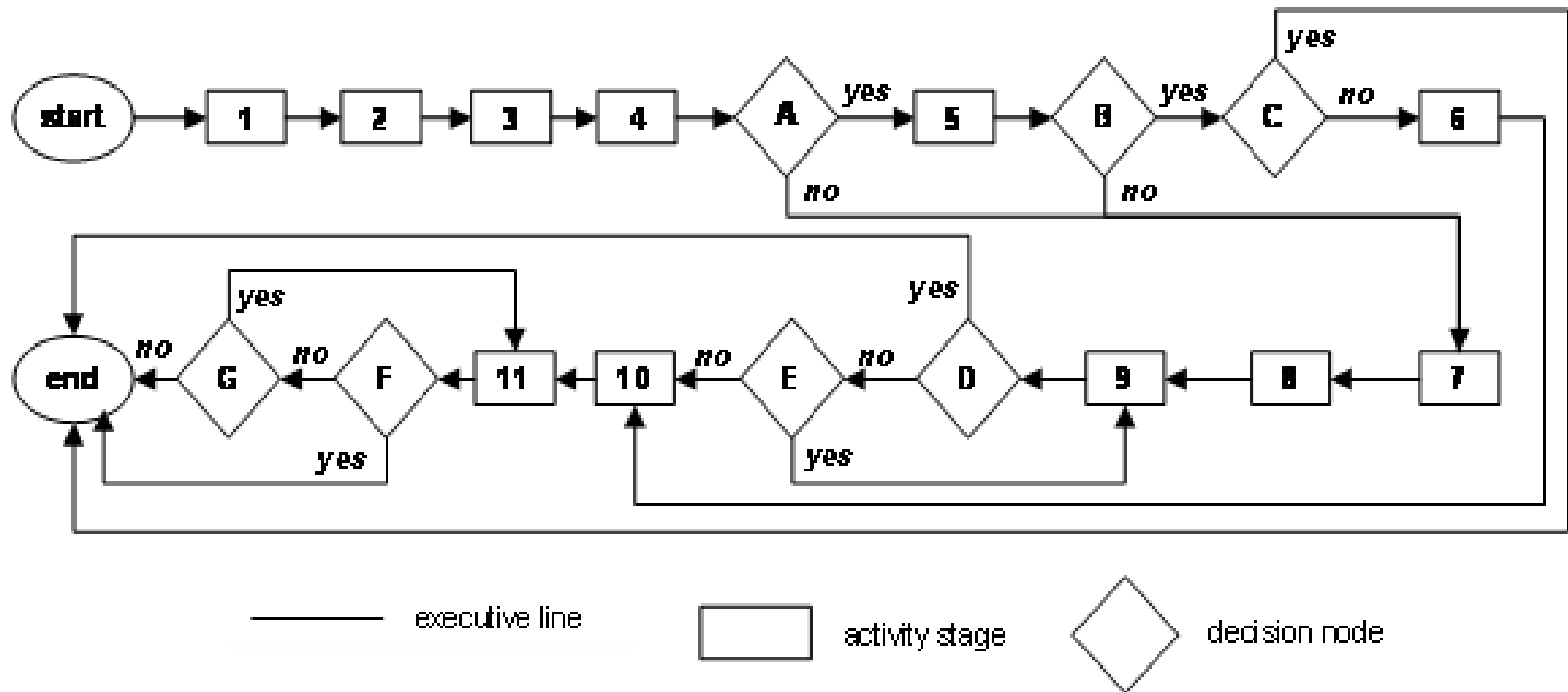
Dimensional analysis was initially developed early in the last century by scientists and engineers

- The first attempt to a similar approach in Economics was made by Allais
- The physical and/or economic magnitudes are usually arranged in dimensionless groups (DGs), the number of which is $m=n-r$, where n is the number of dimensional variables/ parameters/constants (VPCs) and r is the number of primary quantities used, like mass M, length L, time T, and temperature G
- This rule is a general relation based on Linear Algebra and Group Theory and is mostly quoted as Buckingham's pi theorem
- DGs may have physical meaning and in such a case we can search for similar groups through Case Based Reasoning (CBR)

CBR has been formalized for purposes of computer-aided processing as a four-step algorithmic procedure, which might be named 4R from the initial letter of the four verbs used as computer program commands in the corresponding steps:

- (I) Retrieve the cases considered to be relevant to solving a given target problem
- (II) Re-use the solution (if it was successful) from the previous case to the target problem by making the necessary modifications to adapt the solution as needed to fit the new situation
- (III) Revise by testing the solution of the new problem directly in the real world or indirectly under suitable conditions or reliable simulation
- (IV) Retain by storing the solution as a new case in the computer memory, provided that the adaptation was a successful one

The methodological framework we have developed, is presented below: The logical flow chart developed for acquiring/processing/storing/retrieving knowledge for identification and correction of either dimensionally inconsistent VPCs or/and DGs in error.



Working out as above... $B = V\rho/[\mu(1 - \varepsilon)S]$

- The first refers to modified Reynolds or Blake Number, By replacing the units with the corresponding dimensions, we obtain $B \in [LT^{-1}] [ML^{-3}] [ML^{-1}T^{-1}]^{-1} [L^3]^{-1} [L^2L^{-3}]^{-1}$ or $B \in [L^{-3}] \neq [1]$, we obtain $B \in [LT^{-1}][ML^{-3}][ML^{-1}T^{-1}]^{-1} [L]^{-1} [L^2L^{-3}]^{-1}$ or $B \in [L^{-1}] \neq [1]$
- The computerized procedure identified finally the correct dimensions to be $\in [1]$ and $\in [L^{-1}]$, giving $B \in [1]$
- The second case example used for implementation is the Freundlich isotherm :
- $Q = KC^{1/n}$
- where q = the amount of mass adsorbed per unit mass of the adsorbent ; C = the equilibrium concentration of the adsorbate, $[ML^{-3}]$; K = parameter related to adsorption capacity; n = parameter related to adsorption intensity,
- Consequently, we can write the isotherm model in dimensional form as follows: $q = K_s K_d K_t C^{1/n}$, where $q \in [M_d M_t^{-1}]$, $C \in [M_s L^{-3}]$, $K_s \in [M_s^{-1} L^3]^{1/n}$, $K_d \in [M_d]$, $K_t \in [M_t^{-1}]$, which is meaningful as representing the real situation

DISCUSSION AND CONCLUDING REMARKS

$$Q = A\varepsilon^3 P / [K\mu(1 - \varepsilon)^2 S^2 l]$$

- This identification attempt becomes cumbersome and the computer program may fail to suggest a realistic solution without substantial human intervention
- The probability to fail increases when the DG under investigation is incorporated into relations that change the original VPCs with others for sake of better fitting to system's specifications
- When the system is 'fluid flow through porous media', B can be combined with the 'resistance coefficient' DG expressed by the ratio to give a relation of the general form in the procedure known as the Blake-Carman correlation
- where A is the cross-sectional area of packing perpendicular to flow direction, P is the pressure difference, Q is the volumetric flow rate ($Q=VA$), l is the length of packing in the flow direction, K and n are parameters. In the low B -range (approximately, $B<1$), $n=1$
- we obtain the Kozeny-Carman equation, which is dimensionally homogenous, since $Q \in [L^3T^{-1}]$ and $\frac{A\varepsilon^3 P}{[K\mu(1 - \varepsilon)^2 S^2 l]} \in [L^2][1][ML^{-1}T^2][1][ML^{-1}T^1][L^{-1}]^{-2}[L]^{-1}=[L^3T^{-1}]$

In such a case... $Q = A \varepsilon^3 P / [K \mu (1 - \varepsilon)^2 S d]$

- we cannot investigate any dimensional inhomogeneity in B since this DG does not appear *per se* in the final model
- If S is replaced by d in B , then the Kozeny-Carman equation becomes
- consequently, the dimensional vector of the right-hand side of this equation becomes $[LT^{-1}]$ which is inconsistent with the left hand-side dimensional vector $[L^3T^{-1}]$ denoting the correct dimensions of volumetric flow rate Q .
- the IA cannot identify the source of error unless provided with further information corresponding to ancestor relations
- the inference engine searching within the KB may identify Q with the ‘superficial velocity’

In conclusion...

- we have indicated the functionality of the methodological framework presented herein by analyzing two simple cases, one for DG and another for VPC
- if the DGs or VPCs in error have been incorporated/combined into/with other expressions
- traceability decreases and human intervention, at least for changing the searching pattern through CBR
- increases the effectiveness of computer aided performance while facilitates the KB's enrichment/restructuring